Environmental Conservation (2018) **45** (2): 192–202. © Foundation for Environmental Conservation 2017. doi:10.1017/S0376892917000431

Marine resource management and conservation in the Anthropocene

SHANKAR ASWANI[1]*, XAVIER BASURTO[2], SEBASTIAN FERSE[3], MARION GLASER[3], LISA CAMPBELL[2], JOSHUA E. CINNER[4], TRACEY DALTON[5], LEKELIA D. JENKINS[6], MARC L. MILLER[7], RICHARD POLLNAC[5], ISMAEL VACCARO[8] AND PATRICK CHRISTIE[7]

[1]*Department of Anthropology and Department of Ichthyology and Fisheries Science (DIFS), Rhodes University, Grahamstown 6140, South Africa,* [2]*Duke Marine Lab, Nicholas School of the Environment, Duke University, Beaufort, NC 28516, USA,* [3]*Leibniz Center for Tropical Marine Ecology, Fahrenheitstrasse 6, D-28359 Bremen, Germany,* [4]*ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD 4811, Australia,* [5]*Department of Marine Affairs, Coastal Institute, University of Rhode Island, Kingston, RI 02881, USA,* [6]*School for the Future of Innovation in Society, Arizona State University, Tempe, AZ 85287–5603, USA,* [7]*School of Marine and Environmental Affairs and Jackson School of International Studies, University of Washington, 3707 Brooklyn Avenue NE, Seattle, WA 98105-6715, USA and* [8]*Department of Anthropology and McGill School of Environment, McGill University. Montreal, Canada*

Date submitted: 26 October 2016; Date accepted: 25 July 2017; First published online 2 November 2017

SUMMARY

Because the Anthropocene by definition is an epoch during which environmental change is largely anthropogenic and driven by social, economic, psychological and political forces, environmental social scientists can effectively analyse human behaviour and knowledge systems in this context. In this subject review, we summarize key ways in which the environmental social sciences can better inform fisheries management policy and practice and marine conservation in the Anthropocene. We argue that environmental social scientists are particularly well positioned to synergize research to fill the gaps between: (1) local behaviours/needs/worldviews and marine resource management and biological conservation concerns; and (2) large-scale drivers of planetary environmental change (globalization, affluence, technological change, etc.) and local cognitive, socioeconomic, cultural and historical processes that shape human behaviour in the marine environment. To illustrate this, we synthesize the roles of various environmental social science disciplines in better understanding the interaction between humans and tropical marine ecosystems in developing nations where issues arising from human–coastal interactions are particularly pronounced. We focus on: (1) the application of the environmental social sciences in marine resource management and conservation; (2) the development of 'new' socially equitable marine conservation; (3) repopulating the seascape; (4) incorporating multi-scale dynamics of marine social–ecological systems; and (5) envisioning the future of marine resource management and conservation for producing policies and projects for comprehensive and successful resource management and conservation in the Anthropocene.

*Correspondence: Professor Shankar Aswani email: s.aswani@ru.ac.za

Keywords: Anthropocene, environmental social science, marine conservation, social equity, sustainability

INTRODUCTION

The Anthropocene has witnessed humankind becoming a global force of environmental change (Crutzen 2002). The debate on whether the Anthropocene started with the arrival of *Homo sapiens*, the inception of agriculture, colonialism or the beginning of industrialization (e.g. Ruddiman 2003; Smith & Zeder 2013) came to the fore in August 2016 when the scientific community recognized the Anthropocene as a geological reality (Phys.org 2016). While some have questioned its conceptual utility as a social construct (Lövbrand *et al.* 2015) or even its existence as a geological era (Visconti 2014), others clearly place its beginnings according to multiple strands of evidence to the mid-20th century (Waters *et al.* 2016). Human behaviour is now having considerable planetary impacts (e.g. Dirzo *et al.* 2014) and in the oceans these impacts include decreased ocean productivity and altered food web dynamics, the extinction and displacement of many marine species (Gattuso *et al.* 2015; McCauley *et al.* 2015), pollution and sedimentation (Richmond *et al.* 2007), rising sea temperatures and ocean acidification (Hoegh-Guldberg *et al.* 2007).

Environmental social scientists, particularly those who study human–environmental interactions (in all their dimensions) and governance systems, are well positioned to understand human behaviour in the Anthropocene and to translate it to natural scientists and political decision-makers. This is because the present epoch is one where environmental change is largely anthropogenic, driven by human psychological, social, economic and political processes. The environmental social sciences are a constellation of interdisciplinary and multidisciplinary scholarship on past and present human–environmental interactions and associated cognitive, behavioural, economic, governance, political and socio-cultural systems. These approaches present combinations of descriptive, empirically grounded, quantitative, critical/reflexive and qualitative methodologies

and encompass fields as diverse as human ecology, political ecology, ethnobiology, environmental psychology, environmental history, institutional analysis and cultural ecology. Yet the environmental social sciences are not strictly a mission-orientated set of approaches to inform biological conservation or what Bennett *et al.* (2017) have described as "conservation social sciences." Beyond enabling actionable science for conservation, environmental social scientists study the role of humans in environmental change and examine the proximate and ultimate causation mechanisms of human environmental cognition and behaviour, cross-scale dynamics, power asymmetries in resource use and access and approaches to practical environmental solutions from various theoretical and methodological viewpoints. These pluralities, which have similarities and differences, are not well understood or represented in major resource management and conservation debates in the Anthropocene, where economic values and approaches have been emphasized in mainstream management and conservation (e.g. ecosystem services and payments for them). The multiple dimensions of environmental social science need to be translated clearly to conservation practitioners, natural scientists and funders to enhance the various aspects involved in understanding human–nature relations theoretically in order to support the more efficient (and equitable) design of resource management and conservation programmes (see also Drury *et al.* 2011; Cornu *et al.* 2014; Moon & Blackman 2014; Holmes 2015).

In this subject review, we highlight various key ways in which environmental social science can provide a deeper understanding of the human role in marine transformations and provide knowledge to better inform marine and coastal resource management and conservation policy and practice in the Anthropocene. We focus on the co-design and co-implementation of initiatives such as marine protected areas (MPAs), marine ecosystems-based management, marine environmental restoration and fisheries regulations at local, regional and national scales, particularly in developing nations, where issues arising from human–coastal interactions are particularly pronounced. The environmental social sciences are necessary for studying human–marine interactions and resource use and management and conservation in the marine environment because humans need to better understand the past and present human–marine interfaces, as the oceans cover over 70% of the planet's surface and most of humanity lives near the coast. In addition, current and future human interactions with the oceans are crucial for human well-being and survival in the Anthropocene, and it will require serious efforts to manage and conserve the oceans. Thus, we argue that environmental social scientists are particularly well positioned to synergize research to fills the gaps between: (1) local behaviours/needs/worldviews and marine resource management and conservation concerns; and (2) large-scale drivers of planetary marine environmental change (resulting from globalization, affluence, technological change, etc.) and local psychological, socioeconomic, cultural and historical processes that shape human behaviour and knowledge systems. Environmental social scientists, therefore, can scale up from the local to the global and vice versa. The broader objective of this paper is to advocate not only for the involvement of environmental social scientists in co-designing and implementing marine resource management and conservation, but also for their role in the co-production of knowledge, management and governance systems that are more just and enduring in the context of the Anthropocene.

The review synthesizes some key themes in order to stimulate further debate and discussion about the future of marine resource management and conservation initiatives, including: (1) the application of the environmental social sciences in marine resource management and conservation; (2) the development of 'new' socially equitable marine conservation; (3) repopulating the seascape; (4) incorporating multi-scale dynamics of marine social–ecological systems; and (5) envisioning the future of marine resource management and conservation in the Anthropocene. The review is based on cited literature and on our collective experience in co-learning and co-producing knowledge on marine resource management and conservation issues, drawing on a wide range of intellectual perspectives, and diverse geographic regions around the world. The interrelated examples are not meant to be exhaustive, but rather a sample of the diverse environmental social science approaches, theories and methods available for understanding human–marine interactions (e.g. Vaccaro *et al.* 2010) and informing and driving marine resource management and conservation, particularly in coastal areas, where human–environmental entanglements are profuse.

APPLICATION OF ENVIRONMENTAL SOCIAL SCIENCES IN THE MARINE ENVIRONMENT

Although globalization characterizes the Anthropocene, understanding human–environmental interactions and resolving many environmental problems require local research and solutions. Successful policy and appropriate knowledge for designing resource management and conservation in a human-dominated biosphere are often best formulated by scaling down and considering the intricacies of local resource users and their governance and power dynamics. This can lead to the production of knowledge that is different from what is normally applied in the creation and implementation of management and conservation strategies in a global context. Given the mixed record of biologically driven marine conservation policy and projects (e.g. Christie 2004; Lundquist & Granek 2005), it is time to expand efforts in integrating natural and social sciences in the design and implementation of policies and projects for marine conservation and management. Indeed, projects and policy should be based on sound science (both natural and social), an understanding of conservation efforts that are ecologically effective and socially appropriate and the respectful collaboration between social and natural scientists.

https://doi.org/10.1017/S0376892917000431

But this implies equal partnership in responsibilities between social and natural scientists with interdisciplinary training in collaboration with local communities and regional and national officials, who may be more worried about human well-being and development than marine conservation. Such constellations are rare so far, notwithstanding earlier calls for the inclusion of social science in terrestrial (e.g. West & Brechin 1991) and marine conservation (e.g. Mascia *et al.* 2003).

Substantive environmental social science research could increase the effectiveness of coastal fisheries management and conservation plans. For instance, human behavioural ecology has been used as a theoretical framework to understand human foraging propensities in marine diet breadth (food choices; e.g. Thomas 2002) and patch choice (habitat selection; e.g. Aswani 1998) to gauge incipient conservation practices (or not) and their implications in an evolutionary context. It has also been used to understand how social networks based on kinship and habitational proximity increase reciprocal exchanges of whale meat in rural areas of Indonesia (Nolin 2010). This kind of fine-grained human ecological/behavioural information is rarely collected or even understood, yet it is important to elucidate how and why human behaviour is structured in resource extraction and exchanges (and not just social and cultural ideas and perceptions). This information is also important for designing marine resource sustainability and conservation programmes (Heinen 1992) in many parts of the world.

Other environmental social scientists have acknowledged that psychological variables are also important in understanding the attitudes, beliefs and values that impact human interactions with the marine environment in terms of conservation-relevant behaviour. For example, cultural values and beliefs influence attitudes towards conservation-related behaviour in general or climate change (e.g. Price *et al.* 2014). Research has also identified psychological factors associated with fishers' behaviour that frequently confounds fishery management efforts, such as reluctance to leave the occupation of fishing even when declining stocks result in sharply decreasing incomes (e.g. Pollnac *et al.* 2012). Aspects of job satisfaction among fishers have been identified as causal factors in this type of response. Attributes of the occupation such as 'adventure', 'independence' and 'being outdoors', among others, have been identified as functioning as therapy for a specific personality type, which is influenced by both behavioural and cultural factors. In fact, job satisfaction is the most consistent predictor of well-being among fishers (e.g. Seara *et al.* 2017). Today, when human impacts on fisheries stock declines and climate change pose important and increasing challenges for fishers and policy-makers alike in many parts of the world, these psychological aspects of the occupation must be accounted for.

The environmental social sciences can also focus on institutional processes. With two-thirds of the global population living within 100 km of a coast, coastal regions are hotspots of contemporary anthropogenic change. Higher population densities, more direct forms of dependence on nature and more diverse uses in coastal regions (as compared to purely terrestrial and purely marine regions) take the tropical coastal belt into the centre of anthropogenic change processes. Vulnerable tropical coastal ecosystems such as coral reefs are at the frontline of debates regarding human-driven change processes today. The better-preserved coral reefs or 'bright spots' are found in areas of the world that still have strong socio-cultural institutions such as customary management systems and in which high levels of local engagement (often with social scientists, among others) in management are present (Cinner *et al.* 2016). The study of local governance institutions (e.g. resource exploitation and management patterns) and management in these hotspots are at the core of the type of institutional environmental social science research outlined here.

Environmental social sciences have uncovered the attributes of successful decentralized governance systems. The Caguama turtle project (Baja California Sur) shows that local governance system studies can empower small-scale fishermen to improve turtle conservation outcomes (Peckham & Maldonado 2012). While natural science was important in understanding loggerhead hotspots, the use of environmental social science was the driving force in the direct participation of fishermen in the protection of loggerhead turtles and fisheries. The community-based Ostional Egg Harvesting Project (Costa Rica) has for two decades successfully maintained a stable population of nesting Olive Ridley turtles, the key being the consideration of legal and economic aspects as well as the participation of community members in the design and management of the reserve (Campbell *et al.* 2007). In the Indonesian Spermonde archipelago, the strongest evidence of effective reef MPA governance was found to be associated with informal, self-organized island-based institutions (Glaser *et al.* 2010). The use of a geographic information system database to geo-reference governance systems, marine local knowledge and foraging can help in designing culturally contextualized MPAs, and has contributed to a mixed measure of biological and social success in the creation of MPAs in the Western Solomon Islands, where there is no governmental enforcement and policing is conducted by local communities themselves (see Aswani *et al.* 2017).

In a policy-orientated context, environmental social scientists can provide fundamental insights. For instance, at the recent Human Dimensions Think Tank on Large Scale Marine Protected Areas, involving 125 individuals from 17 countries and 16 universities and supported by 7 international donors, an applied social science research agenda was jointly promoted. The idea was that in designing many large MPAs, the agenda had to be implemented by practitioners and social scientists (Christie & Lewis 2016). It was decided that focusing on issues of culture, participatory planning and economic trade-offs was essential to improved management of these areas that include 9 million km^2 of ocean (Big Ocean 2016). This meeting resulted in a commitment to a 'community of practice' and developed a framework for the inclusion of social

https://doi.org/10.1017/S0376892917000431

and cultural dimensions in the planning and implementation of large MPAs (areas over 250 000 km^2). The International Union for Conservation of Nature (IUCN) has recently created a Global Economics and Social Science Programme (GESSP) to further promote and develop the use of the social sciences in conservation; a Social Science for Conservation Fellowship Programme has been launched to demonstrate ways in which social science methods and perspectives can improve understanding of and address challenges related to the human dimensions of conservation (Bennet *et al.* 2017). Such efforts are prompted by findings that MPAs designed purely on size and biological characteristics will not succeed unless "durable management and compliance" parameters are considered in their design at local and global scales (Jones 2002; Edgard *et al.* 2014: 216).

For all the potential contributions, however, environmental social scientists are still underrepresented. An example of this absence is the United States National Oceanic and Atmospheric Administration (NOAA), which has authority over ocean issues in the United States and is mandated by the Magnuson Stevens Act to consider the social impacts of fisheries plans (and also has jurisdiction over many tropical coral reefs in various island locations). Of the six line offices that comprise the NOAA, the National Marine Fisheries Service (NMFS) has the most social scientists on its staff by far. Yet of the NMFS's 1700 employees in Fisheries Science Centers, only 4% are in social science or human dimensions staff positions. Of those in social science or human dimensions staff positions, 68% are economists, while only 11% are anthropologists, 8% are other social scientists and 11% are in human dimensions positions that are non-social science (e.g. journalism) or unclassified positions (NOAA 2017). Social network analysis of the marine resource management scientific community at Puget Sound shows that 80% of researchers are natural scientists, and social science research is only vaguely integrated into management plans (Hoelting *et al.* 2014). These examples by comparison hint at the negative state of social science inclusion in governance elsewhere in the world.

TOWARDS A 'NEW' SOCIALLY EQUITABLE MARINE CONSERVATION

With the declaration of the Anthropocene and recent calls for a 'new' conservation science (Marvier 2013), biodiversity conservation is being redefined (e.g. Dirzo *et al.* 2014). The debate on the 'new' conservation science (Soulé 2013) continues to revolve around issues of biodiversity versus human needs. Many, however, argue that conservation can be effective and ethical only if it accounts for humans and their institutions as an integrative part of the environment (Kareiva & Marvier 2012; Sandbrook *et al.* 2013). We do not argue here that conservation should exist for the sole purpose of serving humanitarian or developmental needs, but rather we assume that all living organisms and associated ecosystems have an inherent right to exist and to flourish. We do argue, however, that for conservation to succeed in the longer term, it must take the 'people and nature' approach (Mace 2014) in a way that is socially and environmentally equitable to those people whose livelihoods are affected by it. For this, the meanings, knowledge and interventions pursued must involve the concerns and voices of many constituents, not just those of credentialed experts or political–economic elites. Resource users are more likely to support marine conservation efforts when their concerns are met, and this is more likely to happen when planning processes are participatory, transparent and equitable (e.g. Ferse *et al.* 2010; Pollnac *et al.* 2010; Jenkins 2015). When environmental and socioeconomic benefits are not fairly distributed, elite capture for short-term gains can lower legitimacy and increase conflict (e.g. Glaser *et al.* 2010). Perceived fairness in the distribution of benefits and burdens not only relates to marine resource management in coastal communities, but also to the regulation of wider societal activities affecting the oceans, such as conversion of coastal or hinterland forests, waste management and carbon emissions and use of renewable energy (e.g. Dreyer & Walker 2013).

Research in political ecology can address issues between justice and environmental management at multiple scales and provide an analysis of the power dynamics between the different actors (social and institutional) historically competing in any given sea/landscape for access and control of its natural resources. Ethnographic studies of this type are particularly well-suited to identifying the context, causes and potential solutions to environmental conflict (Bryant & Bailey 1997). Social survey research and causal inference programme evaluation research designs can also examine how relations between local actors, scientists, conservationists, policy makers and donors affect just and durable conservation practices. For instance, Sievanen *et al.* (2013) have used a political ecology framework for studying asymmetries in power relations between different stakeholders involved in marine conservation in Fiji, and this has had benefits for conceptualizing conservation design and implementation. In this respect, political ecology offers a powerful means to ask about why, for whom, by whom and with whom should marine conservation be implemented in the first place. Political ecology, then, can offer the intellectual basis for uncovering how individual and multiple actors conceptualize, perceive, decide or comply (or not) with the implementation of marine conservation initiatives in any one location. Political ecology has also been a tool to identify problems in the way conservation schemes were developed, helping to develop a critical conservation biology capable of identifying its impact on the social and ecological systems (SESs) it attempts to manage and protect. Sometimes conservation has succeeded at harmonizing the interactions between local populations, external socioeconomic pressures and the environment. Other times, however, it has worsened the power asymmetries unfolding over the territory and the disenfranchising of already marginal populations. This can be a particularly troubling outcome for conservationists who may perceive their efforts as inherently ethical and laudable.

https://doi.org/10.1017/S0376892917000431

Marine conservation efforts can unintentionally create dependency on outside expertise and/or funding while working to build sustainability (Gurney *et al.* 2014). It is thus important to understand how different types of conservation interventions and political structures interact to create local dependency or, alternatively, local entrepreneurialism that benefits human well-being and biodiversity conservation. Ostrom's (2005) design principles can be wrongly interpreted as universal blueprints for success, or a signal of disaster if absent. Environmental social scientists can offer guidance on context to understand when and how these design principles can assist in specific settings and, most importantly, they can actively research their articulation in a given location for the production of new knowledge, particularly for building social–ecological theory (e.g. Campbell 2005; Partelow 2016). When resource users are actively involved in governing their resources, improved social and ecological outcomes are realized (Persha *et al.* 2011). However, it remains challenging to discern and implement effective mixes of rights and responsibilities that local resource users and external actors (e.g. central governments or non-governmental organizations) within particular contexts would need to assume, as well as how they can cooperatively create opportunities for the sustainable use and management of oceans. To be successful, such work will need to be based on interdisciplinary collaborations between conservation practitioners and environmental social scientists, which not only engage in conservation for the production of applied research/actionable science (Palmer 2012), but also for striving to discover theoretically how humans use and adapt to changing environments. Indeed, producing context-independent principles that explain or perfectly predict behaviour, interests and social processes in ocean governance may be impossible. However, learning networks that engage conservation practitioners and environmental social scientists (and other scientists and constituency groups) in a multi-level polycentric ocean governance co-design process of research design and implementation is a powerful tool for breaking down institutional boundaries (e.g. Pietri *et al.* 2015). Principles derived through environmental social science and practical experience can be brought into such learning networks to complement other knowledge and to help guide the application of actionable science and the refinement and adaptation of conservation best practices.

In sum, some of the fundamental needs for understanding the social and ecological contexts in which conservation is implemented are discerning processes such as existing conflicts among various stakeholders, differential forms of local resource governance and knowledge (e.g. sea tenure and ecological knowledge) and the role of resource management and conservation programmes in enhancing or diminishing people's economic prospects. Also important is pinpointing peoples' social values and aesthetic perceptions regarding the environment and analysing how conservation programmes can empower or alienate coastal communities (e.g. Berkes *et al.* 2000; Christie 2004). Importantly for interdisciplinary collaboration, environmental social scientists should not only promote intellectual relativism in the practice of conservation (e.g. West & Brockington 2006; Peterson *et al.* 2010), but also co-produce and co-implement practical knowledge that is engaged *in situ* for the successful implementation of conservation (e.g. Jenkins *et al.* 2012). While there are still some social scientists that reject intervention and prefer to focus solely on studying or deconstructing social phenomena, environmental social scientists can only take a co-leadership role in marine resource management and conservation if they demonstrate on the ground the effectiveness of projects and policies that seek a balance between human and ecological needs. To this end, they also need to demonstrate that resource management and conservation initiatives do not create or perpetuate social and environmental injustices for poor and indigenous minorities.

REPOPULATING THE SEASCAPE

As seascapes in the Anthropocene become increasingly humanized, fractional and encroached upon by economic development, particularly in coastal areas, it is fundamental to recognize the past peopling of the oceans historically. The representation of 'unpeopled seascapes' is more easily sustained both because humans live on land and also since the ocean is often characterized as a vast open-access resource that humans enter to extract benefits and then leave (e.g. Shackeroff *et al.* 2009). Removing people from marine environments (via MPAs or fisheries closures) is then partly justified on society being 'outside' of the marine realm (and this becomes more complicated when MPAs are near urban centres). This is reflected in the paradox of labelling places with a demonstrated recent history of human habitation as marine wilderness (e.g. Graham & McClanahan 2013). Steinberg's (2001) work challenges these assumptions by documenting changing historical and contemporary social 'constructions' of the ocean in Western society and how these influence the contradictory ways in which oceans are managed. In fact, such mental constructions subject the ocean to a highly utilitarian view of the natural environment by mainstream society, and therefore the humanization of the ocean (e.g. by recognizing indigenous territorial rights, oceans as highways of cultural–genetic past interactions, etc.) in the Anthropocene is necessary to address this disjuncture.

Again, this utilitarian view that is so pervasive in the Anthropocene is also reflected in developments in high-seas fishing and deep-sea mining. As these fall outside national boundaries, or straddle several of them, they pose unique and novel challenges to policy and governance. Where these resources fall outside national boundaries, they have traditionally been considered as free for all. While the need for more systematic and concerted approaches to conservation of the high seas is widely recognized (e.g. Ban *et al.* 2014), the discussion again draws largely on natural science perspectives, such as the migratory nature of some fish stocks or the extent of marine ecoregions. Perspectives

https://doi.org/10.1017/S0376892917000431

such as the cultural values attributed to seascapes do not feature in these considerations. A similar trend is apparent in the development of ocean renewable energy and technological mitigation of climate change (e.g. through artificial upwelling of deep ocean waters or the storage of sequestered carbon dioxide in the deep sea). The push for these types of activities is bound to increase greatly in the coming decades. Again, their implementation views the marine space largely through a lens of technological feasibility and oceanographic suitability. Unless different views and perceptions of seascapes are integrated, conflicts over uses of marine space are likely to increase in the future. More than anywhere else, the international policy arena provides a forum for different views of the natural environment to come into conflict, and successful governance of transnational issues requires coming to terms with these often-conflicting views. The ongoing argument over jurisdiction of parts of the South China Sea, with contrasting claims by different nations that are based on contrasting cultural and historical arguments, is one such example. As the recent ruling by the Permanent Court of Arbitration on the issue has shown, biophysical facts have little relevance to the eventual resolution of the disagreements. Rather, socio-cultural and historical knowledge often holds the crucial potential to settle such disputes. Environmental social scientists, and in this case social scientists in general, are well placed to contribute to the debate by assessing and translating the different views, including those that place marine environments as inseparable from identity.

Rich ethnographic documentation of human uses of seascapes provides tangible examples where community territory and property rights have extended to the sea and have helped over generations in the use and sustainable management of marine resources (e.g. Sopher 1965; Johannes 1978; Ruddle 1989). Although eroded during the colonial era, in many island nations, efforts to revive and strengthen traditional marine stewardship are ongoing. A current example is support for the Pacific Islands Ocean Region as 'our sea of islands' (Pratt & Govan 2010). Even in the highly industrialized ground fish fisheries of New England, St Martin (2001) used participatory research methods combined with analysis of vessel monitoring data to find and map communities 'at sea', and others have shown that appropriation of the sea is not restricted to indigenous or far-away rural communities (e.g. Acheson 1988; McCay 1998). In sum, with the increase in conservationists' efforts to create well-defined property rights regimes in marine management and conservation, it is essential to recognize and account for the historical rights and the complexity of ways in which social groups and nations understand, appropriate, use and make rules for their interactions with the ocean.

Maritime cultures often traverse territorial boundaries to form fluid and mobile networks with little adherence to demarcations drawn by administrators or conservationists. To be successful, marine conservation efforts have to account for these perspectives and develop ways that enable the participation of stakeholders that do not conform to spatially fixed notions of social–environment relations (Pauwelussen 2015). Policy makers not only need to recognize the territorial rights of coastal peoples and the socio-cultural intricacies of local property rights, but they also need to be enabled to match social connectivity (e.g. the distance over which people communicate and share resources) with biological connectivity (e.g. the distance over which species function) (Cumming *et al.* 2006; Mills *et al.* 2010). This social connectivity is even acknowledged in the development of science-based, large-scale MPAs in the Pacific Islands, where governments and interested stakeholders involved in the MPA designation and implementation are taking into account the historical context of ancient voyaging and trading, the sense of place that islanders feel for the ocean and customary managerial claims of islanders to foster interest in and compliance with implementation (Friedlander *et al.* 2016). Yet, notwithstanding this acknowledgement, international conventions such as Aichi Target 11 of the Convention on Biological Diversity (CBD), which specifically talks about MPAs, professes the use of 'equitable management' without a proper understanding of what 'equitable' entails (CBD 2011), thus urgently requiring the involvement of environmental social scientists. While marine spatial planning and ecosystems-based management have been offered as platforms to link conservation and societal needs (Douvere 2008), these formal 'Western' managerial systems still need reconciliation with existing local and indigenous systems of management on the ground (such as Pacific Island customary management systems or lobster fishermen territoriality in Maine, USA), and thus require the development of effective, knowledge-based policy recommendations in marine resource management and conservation using the types of expertise outlined in this paper.

INCORPORATING MULTI-SCALE DYNAMICS OF MARINE SOCIAL–ECOLOGICAL SYSTEMS

Because human–environmental interactions are so intertwined in the Anthropocene and landscapes and seascapes are culturally and physically transformed as a result of millennia of human environmental manipulation, we can no longer treat human–environmental relations as uncoupled. In recent years, authors have emphasized that marine environments are coupled SESs, which are affected by individual and collective human activities, and that changes in marine ecosystems affect human society (e.g. Pollnac *et al.* 2010; Kittinger *et al.* 2013). The concept of SESs can help to highlight interactions and promote diagnostic thinking, as well as the development of a common interdisciplinary language in marine conservation (Basurto *et al.* 2013). Yet, while social–ecological theory conceptually bridges the social and natural sciences, some social scientists have felt uneasy about incorporating this paradigm into their work and either have ignored or rejected the concept altogether. This uneasiness emerges from fundamentally different ways in which natural and social scientists understand fundamental theoretical principles such

https://doi.org/10.1017/S0376892917000431

as system boundaries, self-organization (e.g. versus human agency) and function, among other core concepts of SESs. In addition, some social scientists feel uncomfortable with the attempt at unifying natural and social sciences under the umbrella of SES theory, which is at odds with the pluralism of social science research more generally (Olsson *et al.* 2015).

In this respect, environmental social scientists, many of whom subscribe to and write about SESs, can synergize social and natural science because they are often trained to understand and work with ecology and can thus better reconcile concepts and methods that greatly differ between natural and social scientists, including concepts such as agency, conflict, knowledge and power (which are not included in SES theory). This is particularly relevant in scaling-up for understanding people's relationship to the environment and using this knowledge for marine conservation. Assessing larger-scale processes can help predict trends in marine resource use before they manifest at the local level. However, the study of coupled human–natural systems also needs to scale down for identifying the drivers of resource conceptualization, use and governance, power asymmetries in appropriation and management, among others, in any one location. Only by doing so are we able to assess the outcomes of interacting global drivers and place-specific institutions (Berkes *et al.* 2006; Glaser *et al.* 2012). By identifying how individual actors impact the environment at finer spatial and temporal scales, the environmental social sciences can add a crucial missing element to better our understanding of the interrelated mechanisms that shape and drive changes in SESs. Harnessing more systematic research traditions in human ecology, environmental economics and human geography can help in this endeavour. In sum, a problem-focused or issue-based approach to defining SESs opens up options for analysing complex multi-level relationships for one or several multi-level SESs, which may even share the same geographical reference territory (Glaser *et al.* 2012).

Understanding social–ecological systems within their historical contexts, including drivers and feedback loops over time, should inform the design of conservation interventions. For instance, Cinner *et al.* (2012) have incorporated social and ecological measures of performance in coral reef systems and found that market access and users' dependence on resources affect resource conditions, while institutional characteristics (e.g. access restrictions and sanctions) strongly influence livelihoods and compliance outcomes. Incorporating these multiple performance measures facilitates identifying complex relationships and outcomes (Agrawal & Chhatre 2011; Dalton *et al.* 2015), such as increases in some groups' human well-being despite declining ecosystem conditions, or short-term improvements in biological resources as conflicts among stakeholders emerge. This kind of research can also assist in assessing social and ecological linkages in the study of iconic MPAs such as the Galapagos National Park and the Great Barrier Reef Marine Park (Fidelman 2014) for improving their design. In short, by understanding the dynamics of human–environmental relationships locally as the outcome of processes on various scales and system levels, we can improve cross-scale linkages in analyses regarding continuing social and ecological feedbacks in complex marine systems. Then we can conceptualize the globalization of environmental pressure in the Anthropocene in order to take international action for the conservation of marine and terrestrial ecosystems alike.

CONCLUSION: ENVISIONING THE FUTURE OF MARINE CONSERVATION

In the context of the Anthropocene, we have argued that beyond engaging the social sciences and humanities with the natural sciences in general (Palsson *et al.* 2013), meaningful engagement with a diverse range of environmental social science perspectives, insights and experiences will increase the chances for a better theoretical understanding of human–environmental interactions and for successful conservation initiatives. As humans navigate into the Anthropocene, the next decade offers a frontier of opportunities for action-based environmental social science in marine resource management and conservation. Human-driven changes in marine ecosystems (e.g. climate change) open 'new' opportunities to rethink what 'territories' or 'governance regimes' are, and offer the potential to imagine and propose regimes that better take into account marine resource management and conservation objectives and values. Oceans are rich as creative spaces for human ingenuity; they are where the foundations of international law were developed and where communal property management and co-management experiments are taking place (e.g. new fisher unions or community-supported fisheries organizations). While our discussion has focused on near-shore marine management and conservation, other marine issues such as ocean acidification, rising sea levels, plastics, hypoxic zones, fishing in the high seas, large-scale MPAs or deep-sea mining are likely to lead the way in terms of transnational policy development and will require the cooperation of social and natural scientists with society at large to solve them. Because marine environments are underwater and their changes are thus not immediately recognizable, modern social constructions of seascapes have resulted in de-facto marine uses that treat marine areas as open-access resources. A fundamental issue in the Anthropocene is that socially constructed perceptions of ocean spaces, social–ecological changes and causality are difficult to align with scientifically established biophysical causal links. This is because agency or events occur at multiple scales from the local to the global, yet the environmental consequences are clearly local to most people (also because natural and social scientists, environmentalists and non-scientists often have different worldviews).

Marine resource management and conservation of seascapes in the Anthropocene, therefore, must adapt to this overlapping of varied perceptions and conditions. The analysis of marine social–ecological systems needs to attend to the

https://doi.org/10.1017/S0376892917000431

intersection of ecological, behavioural and social processes, where investigations of the latter move beyond a focus mainly on economics as the 'social' component. Understandings of psychological and behavioural processes are also essential to a complete understanding of human behaviour with regard to marine management and conservation activities. Multiple methods of analysis (e.g. including cognitive science, ethnography, participatory research and institutional analysis) are necessary for increasing the possibility of uncovering different powers and behavioural dynamics and hence establishing a participatory decision-making process that elevates the chances of success via local involvement in marine conservation. But achieving truly environmental socially driven and participatory research will require scientists, donors, conservation practitioners and policy makers to: (1) stop viewing social and participatory action research as challenging the primacy of knowledge generation by natural scientists; (2) consider the possibility of interdisciplinary participatory research in which environmental social scientists are involved in all stages of research design, data collection, analysis, policy recommendation formulation and action taking (rather than acting as late-coming data gatherers for natural scientists) (Viseu 2015); (3) recognize the fluidity of local knowledge systems and avoiding their essentialization and commoditization (Sillitoe 1998; Gururani & Vandergeest 2014); (4) consider meaningful and practical solutions to pressing environmental and social problems as important as robust theory generation; (5) remain open to multiple solutions and mechanisms to environmental problems rather than using research in an instrumentalist manner to convince constituents that a particular solution (e.g. protected areas or formal fisheries management plans) is the only and ideal one (in this respect, non-sectarian scenario experiments, in which participants actively discard their disciplinary biases for collective agreements on ways forward in marine conservation, are a good place to start in tackling 'wicked problems'; see Le Heron *et al.* 2016); and (6) consider 'promoting' more environmental social scientists with interdisciplinary training to equal positions of leadership in conservation programmes, particularly for projects in coastal communities that are highly dependent on marine resources. In sum, through a different kind of knowledge production that has been applied to date in the creation, production and implementation of conservation strategies, humanity may find alternative ways of managing the marine environment.

In conclusion, we argue that a key challenge in integrating environmental social sciences into marine conservation practice hinges on recognizing and meaningfully involving the diversity of interests, values, worldviews, knowledge and skills of people closely involved with oceans, as well as of those people whose effects on the oceans occur more indirectly (e.g. through particular lifestyle choices). Harnessing such diversity towards imagining new possibilities and opportunities will help tackle the new dimensions of the challenges that the Anthropocene entails by improving human chances at achieving socially equitable and enduring conservation that benefits both nature and human well-being.

ACKNOWLEDGEMENTS

Jill Belsky, Kai Lee, Phil Levin and Brian Silliman offered useful comments on earlier drafts. The University of Washington School of Marine and Environmental Affairs financed and hosted the Human Dimensions of the Ocean workshop. There is no conflict of interests including any financial, personal or other relationships with other people or organizations.

FINANCIAL SUPPORT

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

CONFLICT OF INTEREST

None.

ETHICAL STANDARDS

None.

References

Acheson, J. (1988) *Lobster Gangs of Maine*. Hanover, NH, USA: University Press of New England.

Agrawal, A. & Chhatre, A. (2011) Against mono-consequentialism: multiple outcomes and their drivers in social–ecological systems. *Global Environmental Change* **21**: 1–3.

Aswani, S. (1998) Patterns of marine harvest effort in southwestern New Georgia, Solomon Islands: resource management or optimal foraging? *Ocean and Coastal Management* **40**: 207–235.

Aswani, S., Albert, S. & Love, M. (2017) One size does not fit all: critical insights for effective community-based resource management in Melanesia. *Marine Policy* **81**: 381–391.

Ban, N.C., Bax, N.J., Gjerde, K.M., Devillers, R., Dunn, D.C., Dunstan, P.K. *et al.* (2014) Systematic conservation planning: a better recipe for managing the high seas for biodiversity conservation and sustainable use. *Conservation Letters* **7**: 41–54.

Basurto, X., Gelcich, S. & Ostrom, E. (2013) The social–ecological system framework as a knowledge classificatory system for benthic small-scale fisheries. *Global Environmental Change* **23**: 1366–1380.

Bennett, N.J., Roth, R., Klain, S.C., Chan, K., Christie, P., Clark, D.A. *et al.* (2017) Conservation social science: understanding and integrating human dimensions to improve conservation. *Biological Conservation* **205**: 93–108.

Berkes, F., Colding, J. & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* **10**: 1251–1262.

Berkes, F., Hughes, T.P., Steneck, R.S., Wilson, J.A., Bellwood, D.R., Crona, B. *et al.* (2006) Globalization, roving bandits, and marine resources. *Science* **311**: 1557–1558.

Big Ocean (2016). About Big Ocean [www document]. URL http://bigoceanmanagers.org/about/

https://doi.org/10.1017/S0376892917000431

Bryant, R. & Bailey, S. (1997) *Third World Political Ecology*. London, UK: Routledge.

Campbell, L.M. (2005) Overcoming obstacles to interdisciplinary research. *Conservation Biology* **19**: 574–577.

Campbell, L.M., Haalboom, B.J. & Trow, J. (2007). Sustainability of community-based conservation: sea turtle egg harvesting in Ostional (Costa Rica) ten years later. *Environmental Conservation* **34**: 122–131.

CBD (2011) Strategic Plan for Biodiversity (2011-2020) [www document]. URL https://www.cbd.int/sp/targets/rationale/target-11/

Christie, P. (2004) Marine protected areas as biological successes and social failures in Southeast Asia. *American Fisheries Society Symposium* **42**: 155–164.

Christie, P. & Lewis, N. (2016) Perspective: report on the think tank on human dimensions of large scale MPAs. *MPAnews* **17**: 5–6.

Cinner, J.E., McClanahan, T.R., MacNeil, M.A., Graham, N.A., Daw, T.M., Mukminin, A. *et al*. (2012) Comanagement of coral reef social–ecological systems. *Proceedings of the National Academy of Sciences of the United States of America* **109**: 5219–5222.

Cinner, J.E., Huchery, C., MacNeil, M.A., Graham, N.A., McClanahan, T.R., Maina, J. *et al*. (2016). Bright spots among the world's coral reefs. *Nature* **535**: 416–419.

Cumming, G.S., Cumming, D.H.M. & Redman, C.L. (2006) Scale mismatches in social–ecological systems: causes, consequences, and solutions. *Ecology and Society* **11**: 14.

Cornu, E.L., Kittinger, J.N., Koehn, J.Z., Finkbeiner, E.M. & Crowder, L.B. (2014) Current practice and future prospects for social data in coastal and ocean planning. *Conservation Biology* **28**: 902–911.

Crutzen, P.J. (2002) Geology of mankind. *Nature* **415**: 23.

Dalton, T., Forrester, G. & Pollnac, R. (2015) Are Caribbean MPAs making progress toward their goals and objectives? *Marine Policy* **54**: 69–76.

Dirzo, R., Young, H.S., Galetti, M., Ceballos, G., Isaac, N.J.B. & Collen, B. (2014) Defaunation in the Anthropocene. *Science* **345**: 401–406.

Douvere, F. (2008) The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy* **32:** 762–771.

Dreyer, S.J. & Walker, I. (2013) Acceptance and support of the Australian carbon policy. *Social Justice Research* **26**: 343–362.

Drury, R., Homewood, K. & Randall, S. (2011) Less is more: the potential of qualitative approaches in conservation research. *Animal Conservation* **14**: 18–24.

Edgar, G.J., Stuart-Smith, R.D., Willis, T.J., Kininmonth, S., Baker, S.C., Banks, S. *et al*. (2014) Global conservation outcomes depend on marine protected areas with five key features. *Nature* **506**: 216–220.

Ferse, S.C.A., Máñez Costa, M., Schwerdtner Máñez, K., Adhuri, D.S. & Glaser, M. (2010) Allies, not aliens: increasing the role of local communities in marine protected area implementation. *Environmental Conservation* **37**: 23–34.

Fidelman, P.I.J. (2014) Climate change adaptation in the Great Barrier Reef iconic national park system. *The George Wright Forum* **31**: 270–279.

Friedlander, A.M., Wagner, D., Gaymer, C.F., Wilhelm, T.A., Lewis, N.A., Brooke, S. *et al*. (2016) Co-operation between large-scale MPAs: successful experiences from the Pacific Ocean. *Aquatic Conservation: Marine and Freshwater Ecosystems* **26**: 126–141.

Gattuso, J.P., Magnan, A., Billé, R., Cheung, W.W.L., Howes, E.L., Joos, F. *et al*. (2015) Contrasting futures for ocean and society from different anthropogenic CO_2 emissions scenarios. *Science* **349**: 4722.

Glaser, M., Baitoningsih, W., Ferse, S.C.A., Neil, M. & Deswandi, R. (2010) Whose sustainability? Top-down participation and emergent rules in marine protected area management in Indonesia. *Marine Policy* **34**: 1215–1225.

Glaser, M., Krause, G., Halliday, A. & Glaeser, B. (2012) Towards global sustainability analysis in the Anthropocene. In: *Human–Nature Interaction in the Anthropocene: Potentials of Social–Ecological Systems Analysis*, eds. M. Glaser *et al*., 193–222. London, UK: Routledge.

Graham, N.A.J. & McClanahan, T.R. (2013) The last call for marine wilderness? *Bioscience* **63**: 397–402.

Gurney, G., Cinner, J., Ban, N., Pressey, R., Pollnac, R., Campbell, S. *et al*. (2014) Poverty and protected areas: an evaluation of a marine integrated conservation and development project in Indonesia. *Global Environmental Change* **26**: 98–107.

Gururani, J. & Vandergeest, P. (2014) Introduction: new frontiers of ecological knowledge: co-producing knowledge and governance in Asia. *Conservation and Society* **12**: 343–351.

Heinen, J.T. (1992). Human behavioural ecology and environmental conservation. *Environmental Conservation* **19**: 105–116.

Hoelting, K., Moore, B., Pollnac, R. & Christie, P. (2014) Collaboration within the Puget Sound marine and nearshore science network. *Coastal Management* **42**: 332–354.

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E. *et al*. (2007). Coral reefs under rapid climate change and ocean acidification. *Science* **318**: 1737–1742.

Holmes, G. (2015) What do we talk about when we talk about biodiversity conservation in the Anthropocene? *Environment and Society* **6**: 87–108.

Jenkins, L.D. (2015) From conflict to collaboration: the role of expertise in fisheries management. *Ocean and Coastal Management* **103**: 123–133.

Jenkins, L.D., Maxwell, S.M. & Fisher, E. (2012) Using embedded experiences and upstream elicitation to increase conservation impact and better align research with policy needs. *Conservation Biology* **26**: 740–742.

Johannes, R.E. (1978) Traditional marine conservation methods in Oceania and their demise. *Annual Review of Ecology and Systematics* **9**: 349–364.

Jones, P.J. (2002). Marine protected area strategies: issues, divergences and the search for middle ground. *Reviews in Fish Biology and Fisheries* **11**: 197–216.

Kareiva, P. & Marvier, M. (2012) What is conservation science? *BioScience* **62**: 962–969.

Kittinger, J.N., Finkbeiner, E.M., Ban, N.C., Broad, K., Carr, M.H., Cinner, J.E. *et al*. (2013). Emerging frontiers in social–ecological systems research for sustainability of small-scale fisheries. *Current Opinion in Environmental Sustainability* **5**: 352–357.

Le Heron, R., Lewis, N., Fisher, K., Thrush, S., Lundquist, C., Hewitt, J. & Ellis, J. (2016). Non-sectarian scenario experiments in socio-ecological knowledge building for multi-use marine environments: insights from New Zealand's Marine Futures project. *Marine Policy* **67**: 10–21.

Lövbrand, E., Beck, S., Chilvers, J., Forsyth, T., Hedrén, J., Hulme, M., Lidskog, R. & Vasileiadou, E. (2015) Who speaks for the future

of Earth? How critical social science can extend the conversation on the Anthropocene. *Global Environmental Change* **32**: 211–218.

Lundquist, C.J. & Granek, E.F. (2005) Strategies for successful marine conservation: integrating socio-economic, political, and scientific factors. *Conservation Biology* **19**: 1771–1778.

Mace, G. (2014) Whose conservation? *Science* **345**: 1558–1560.

Marvier, M. (2013). New conservation: friend or foe to the traditional paradigm? *Science for Nature and People Magazine* [www document]. URL http://snappartnership.net/magazine/new-conservation-friend-or-foe/

Mascia, M.B., Brosius, J.P., Dobson, T.A., Forbes, B.C., Horowitz, L., McKean, M.A. & Turner, N.J. (2003) Conservation and the sciences. *Conservation Biology* **17**: 649–650.

McCauley, D.J., Pinsky, M.L., Palumbi, S.R., Estes, J.A., Joyce, F.H. & Warner, R.R. (2015) Marine defaunation: animal loss in the global ocean. *Science* **347**: 6219.

McCay, B. (1998) *Oyster Wars and the Public Trust*. Tucson, AZ, USA: University of Arizona Press.

Mills, M., Pressey, R.L., Weeks, R., Foale, S. & Ban, N.C. (2010) A mismatch of scales: challenges in planning for implementation of marine protected areas in the Coral Triangle. *Conservation Letters* **3**: 291–303.

Moon, K., & Blackman, D. (2014) A guide to understanding social science research for natural scientists. *Conservation Biology* **28**: 1167–1177.

NOAA (2017). National Oceanic and Atmospheric Administration staff directory [www document]. URL http://www.nefsc.noaa.gov/read/socialsci/staff.html

Nolin, D.A. (2010.) Food-sharing networks in Lamalera, Indonesia. *Human Nature* **21**: 243–268.

Olsson, L., Jerneck, A., Thoren, H., Persson, J. & O'Byrne, D. (2015). Why resilience is unappealing to social science: theoretical and empirical investigations of the scientific use of resilience. *Science Advances* **1**: e1400217.

Ostrom, E. (2005) *Understanding Institutional Diversity*. Princeton, NJ, USA: Princeton University Press.

Palmer, M.A. (2012). Socioenvironmental sustainability and actionable science. *BioScience* **62**: 5–6.

Palsson, G., Szerszynski, B., Sörlin, S., Marks, J., Avril, B., Crumley, C. *et al*. (2013) Reconceptualizing the 'Anthropos' in the Anthropocene: integrating the social sciences and humanities in global environmental change research. *Environmental Science & Policy* **28**: 3–13.

Pauwelussen, A.P. (2015) The moves of a Bajau middlewoman: understanding the disparity between trade networks and marine conservation. *Anthropological Forum* **25**: 329–349.

Partelow, S. (2016) Coevolving Ostrom's social–ecological systems (SES) framework and sustainability science: four key co-benefits. *Sustainability Science* **11**: 399–410.

Peckham, S.H. & Maldonado-Diaz, D. (2012) Empowering small-scale fishermen to be conservation heroes: a trinational fishermen's exchange to protect loggerhead turtles. In: *Sea Turtles of the Eastern Pacific Ocean: Natural History, Conservation Challenges and Signs of Success*, ed. J.A. Seminoff, pp. 279–301. Tucson, AZ, USA: University of Arizona Press.

Persha, L., Agrawal, A. & Chhatre, A. (2011) Social and ecological synergy: local rulemaking, forest livelihoods, and biodiversity conservation. *Science* **331**: 1606–1608.

Peterson, R.B., Russell, D., West, P. & Brosius, J.P. (2010) Seeing (and doing) conservation through cultural lenses. *Environmental Management* **45**: 5–18.

Phys.org (2016) The Anthropocene is here: scientists [www document]. URL http://phys.org/news/2016-08-anthropocene-scientists.html

Pietri, D.M., Stevenson, T.C. & Christie, P. (2015) The Coral Triangle Initiative and regional exchanges: strengthening capacity through a regional learning network. *Global Environmental Change* **33**: 165–176.

Pratt, C. & Govan, H. (2010) *Our Sea of Islands, Our Livelihoods, Our Oceania. Framework for a Pacific Oceanscape: A Catalyst for Implementation of Ocean Policy*. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme (SPREP).

Price, J.C., Walker, I.A. & Boschetti, F. (2014) Measuring cultural values and beliefs about environment to identify their role in climate change responses. *Journal of Environmental Psychology* **37**: 8–20.

Pollnac, R., Christie, P., Cinner, J.E., Dalton, T., Daw, T.M., Forrester, G.E. *et al*. (2010) Marine reserves as linked social–ecological systems. *Proceedings of the National Academy of Sciences of the United States of America* **107**: 18262–18265.

Pollnac, R.B., Bavinck, M. & Monnereau, I. (2012) Job satisfaction in fisheries compared. *Social Indicators Research* **109**: 119–133.

Richmond, R.H., Rongo, T., Golbuu, Y., Victor, S., Idechong, N., Davis, G., Kostka, W., Neth, L. & Hamnett, M., Wolanski, E. (2007) Watersheds and coral reefs: Conservation science, policy, and implementation. *Bioscience* **57**: 598–607.

Ruddiman, W.F. (2003) The anthropogenic greenhouse era began thousands of years ago. *Climatic Change* **61**: 261–293.

Ruddle, K. (1989) Social principles underlying traditional inshore fishery management systems in the Pacific Basin. *Marine Resourse Ecology* **5**: 231–243.

Sandbrook, C., Adams, W.M., Büscher, B. & Vira, B. (2013) Social research and biodiversity conservation. *Conservation Biology* **27**: 1487–1490.

Shackeroff, J.M., Hazen, E.L. & Crowder, L.B. (2009) The oceans as peopled seascapes. In: *Ecosystem-based Management for the Oceans*, eds. K.L. McLeod & H.M. Leslie, pp. 33–54. Washington, DC, USA: Island Press.

Seara, T., Pollnac, R.B., Poggie, J.J., Garcia-Quijano, C., Monnereau, I. & Ruiz, V. (2017) Fishing as therapy: impacts on job satisfaction and implications for fishery management. *Ocean & Coastal Management* **141**: 1–9.

Sillitoe, P. (1998) The development of indigenous knowledge. A new applied anthropology. *Current Anthropology* **39**: 223–252.

Sievanen, L., Gruby, R.L. & Campbell, L.M. (2013) Fixing marine governance in Fiji? The new scalar narrative of ecosystem-based management. *Global Environmental Change* **23**: 206–216.

Sopher, D.E. (1965) *The Sea Nomads: A Study Based on the Literature of the Maritime Boat People of Southeast Asia*. Singapore: Printed by Lim Bian Han, Govt. Printer.

Smith, B.D. & Zeder, M.A. (2013) The onset of the Anthropocene. *Anthropocene* **4**: 8–13.

Soulé, M. (2013) The 'new conservation'. *Conservation Biology* **27**: 895–897.

St Martin, K. (2001) Making space for community resource management in fisheries. *Annals of the Association of American Geographers* **91**: 122–142.

Steinberg, P. (2001) *The Social Construction of the Ocean*. Cambridge, UK: Cambridge University Press.

Thomas, F.R. (2002) An evaluation of central-place foraging among mollusk gatherers in Western Kiribati, Micronesia: linking behavioral ecology with ethnoarchaeology. *World Archaeology* **34**: 182–208.

Waters, C.N., Zalasiewicz, J., Summerhayes, C., Barnosky, A.D., Poirier, C., Gałuszka, A. *et al.* (2016) The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* **351**: aad2622.

West, P.C. & Brechin, S.R. (1991) *Resident Peoples and National Parks: Social Dilemmas and Strategies in International Conservation*. Tucson, AZ, USA: University of Arizona Press.

West, P. & Brockington, D. (2006) An anthropological perspective on some unexpected consequences of protected areas. *Conservation Biology* **20**: 609–616.

Vaccaro, I., Smith, E.A. & Aswani, S., eds. (2010) *Environmental Social Sciences: Methods and Research Design*. Cambridge, UK: Cambridge University Press.

Visconti, G. (2014) Anthropocene: another academic invention? *Rendiconti Lincei* **25**: 381–392.

Viseu, A. (2015) Integration of social science into research is crucial. *Nature* **525**: 291.

https://doi.org/10.1017/S0376892917000431